Module Handbook Oldenburg

School of Mathematics and Science, Institute of Physics,

Module: Energy Resources and Systems [PRE405]

Duration:	1 semester	Teaching form:	Lectures
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	6 ECTS
Level:	MM (master module)	Workload:	180 hours
This module should be taken in:	1st semester	Required attendance:	52 hours
Person responsible for the study programme: Prof. Dr. Carsten Agert		Persons responsible for this module: Dr. Detlev Heinemann, Dr. Herena Torío	
Alternative person(s) responsible for this module: -		Examiner(s): the previously named persons	

Objective of the module / learning outcomes:

After successful completion of the module students should be able to:

- characterise the global energy system and analyse the structure and constraints of today's energy system
- explain the availability and connection between solar and wind energy
- identify the problems and challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles
- relate the solar irradiance conversion process as well as the atmospheric radiation balance of the earth to Wind Energy Meteorology

Content of the module**:**

This module will give an overview on the global energy system and the challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles.

Energy Meteorology (Lecture – 90 h workload)

Section I: Solar Irradiance

- Radiation Laws
- Solar Geometry
- Interaction of solar irradiance with the atmosphere
- Radiation Climatology
- Solar Radiation Model
- Statistical Properties of Solar Irradiance
- Measuring devices to ascertain Solar Radiation balance
- Satellite-supported data acquisition to assess Solar Irradiance

Section II: Wind Flow

- Origin and Potential of atmospheric energy movements, Heat balance of the atmosphere
- Physical laws of atmospheric flow
- Wind circulation in the atmosphere, Local Winds
- Wind flow in atmospheric layers (Vertical Structure, Ekman Layer)
- Assessment of Wind potential (European Wind Atlas: Model, Concept
- Wind Measurements

Energy Systems (Lecture – 90 h workload)

- Definitions, separation electrical - thermal energy use
- Resources & reserves
- Energy system analysis: Efficiencies at various levels of the energy chain; Exergy analysis
- Energy scenarios
- Climate Change
- Advanced (power plant) technologies for conventional fuels
- Electric power systems with large shares of renewables

Suggested reading:

Energy Meteorology:

- IEA Word Energy Outlook (http://wordenergyoutlook.org/)
- Iqbal, M. 1984: An Introduction to Solar Radiation, Academic Press, Toronto
- Liou, K.-N. 2002: An Introduction to Atmospheric Radiation, Academic Press: 2nd edition
- Peixoto, J.P. & Oort A.H. 2007: Physics of Climate Book, Surge Publishing
- Rasmussen, B. 1988: Wind Energy, 2, Routledge: 1st edition
- Sathyajith, M. 2006: Wind energy: fundamentals, resource analysis and economics, Springer
- Stull, R.B. 1988: An Introduction to Boundary Layer Meteorology, Springer 1st edition

Energy Systems:

- Ramage, J.: Energy: A Guide Book (Oxford University Press, 1997)
- Boyle, G. et al. (Eds.): Energy Systems and Sustainability (Oxford University Press, 2003)
- Blok, K.: Introduction to Energy Analysis (Techne Press, Amsterdam, 2007)
- Houghton, J.: Global Warming: The Complete Briefing, 5th Ed. (Cambridge University Press, 2015)
- UNDP (Ed.): World Energy Assessment: Energy and the Challenge of Sustainability (2000/2004), http://www.undp.org/energy/weapub2000.htm
- GEA: Global Energy Assessment – Toward a Sustainable Future (Cambridge University Press & International Institute for Applied System Analysis, Laxenburg, 2012), www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/Chapters_Home.en.html
- Goldemberg, J. et al.: Energy for a Sustainable World (Wiley Eastern, 1988)
- Nakicenovic, N., A. Grübler and A. McDonald (Eds.): Global Energy Perspectives (Cambridge University Press, Cambridge, 1998).
- Khartchenko, N.V.: Advanced Energy Systems (Taylor & Francis, 1998)
- IEA (International Energy Agency): World Energy Statistics and Balances 2015
- BP: Statistical Review of World Energy 2016 (http://www.bp.com/en/global/corporate/energy-economics.html)
- EIA: International Energy Outlook 2016 (www.eia.doe.gov/forecasts/ieo/)
- United Nations: 2013 Energy Statistics Yearbook (2016) (unstats.un.org/unsd/energy/yearbook/)

Comments: -	Helpful previous knowledge: n/a
Weblink: n/a	Associated with the module(s): n/a
Prerequisites for admission: n/a	
Maximum number of students / selection criteria 50 (PPRE & EUREC students have priority)	
Requirements for awarding the credit points Written Exam 120 min	
Examination periods: Before the end of the lecture period	
Additional Recommendations: n/a	
Registration procedure: Stud.IP	
Last update: 20.07.2017	
Abbreviations: V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical–practical seminar	

School of Mathematics and Science, Institute of Physics,

Module: Renewable Energy Technologies I [PRE410]

Duration:	1 semester	Teaching form:	Lectures, Seminars, Exercises
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	12 ECTS
Level:	MM (master module)	Workload:	360 hours
This module should be taken in:	1st semester	Required attendance:	112 hours

Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Carsten Agert, Hans-Gerhard Holtorf PhD
Alternative person(s) responsible for this module: Prof. Dr. Michael Wark, Dr. Michael Hölling, Dr. Robin Knecht, Dr. Alexandra Pehlken, Prof. Dr. Robert Steinberger-Wilckens, Dr. Herena Torio	Examiner(s): the previously named persons

Objective of the module / learning outcomes:

After successful completion of the module students should be able to:

- critically evaluate and compare three major Renewable Energy conversion processes and technologies: photovoltaics, wind energy and one out of three of solar thermal energy, biomass energy or hydro power.
- critically appraise various electrochemical storage processes and the respective storage techniques
- analyse various system components and their interconnections within a complex Renewable Energy supply system.
- evaluate the Renewable Energy supply systems' operational size and efficiency.
- critically evaluate non-technical impact and side effects when implementing renewable energy supply systems

Content of the module**:**

This module will give an overview over a selection of the major renewable energy technologies and some possibilities of their storage. The focus is on the scientific principles of components and the technical description of the components. Further detailed system analysis will be presented in other modules.

Photovoltaics (Lecture – 90 h workload)

Physics of PV:

- Basic and most important properties of solar radiation related to photovoltaics
- PV cells basics: Fundamental physical processes in photovoltaic materials
- Characterisation and basic modelling of solar cells

Component Description:

- PV generator
- Charge controller
- Inverter
- Balance of system components

System Description

- Grid Connected System
- Stand Alone System

Basics of Wind Energy (Lecture – 90 h workload)

- Wind characterization and anemometers
- Aerodynamic aspects of wind energy conversion
- Wind turbine performance
- Design of wind turbines
- Dimensional analysis and pi-theorem

Fuel Cells & Energy Storage (Lecture – 90 h workload)

- Fundamentals of electrochemistry and thermodynamics, energy and environmental balances
- Basics of hydrogen production - starting materials, processes, efficiencies, environmental impacts
- Basics of fuel cells function, materials, construction, systems, applications
- Fundamental setup of most common battery types
- Fundamental chemical reactions in these batteries
- Operational characteristics, weir processes and service lives of these batteries.

Solar Thermal Energy, Biomass Energy, Hydro Power

Students select one out of the three units:

a. Solar Thermal Energy (90 h workload)
b. Biomass Energy (90 h workload)
c. Hydro Power (90 h workload)

For EUREC Students is highly recommended to choose the Biomass Energy Lecture in order to achieve a broader overview on different renewable energy technologies.

Solar Thermal Energy (Seminar & Exercises – 90 h workload)

- Assessment of solar thermal ambient parameters: regional global, diffuse, reflected solar radiation on horizontal and on tilted plane, ambient temperature
- Solar thermal collectors
- Solar thermal heat exchangers
- Solar thermal storages
- Solar thermal systems and their operation
- Characterization of solar thermal systems

Biomass Energy (Lecture – 90 h workload)

- Energy mix overview; gas, heat, electricity, Pros & Cons of biomass
- Chemical composition of biomass: sugar, cellulose, starch, fats. Oils, proteins, lignin
- Natural photosynthesis in plants: chemical storage of solar energy; general mechanisms
- Chemistry & Biology (microorganism) of Biogas Technology
- Conversion processes of biomass: classification, main pathways
- Introduction to catalysis used in biomass conversion
- Chemical fuels (chemical energy storage) from biomass, routes to platform chemicals and separation processes
- Technology concepts for bioenergy usage
- Introduction into economical and legal constraints

Hydro Power (Seminar & Exercises – 90 h workload)

- Theoretical background – general hydraulic terms, Bernoulli Equation, Major Empirical Formulae and their backgrounds
- Water Resource – catchment area, seasonal precipitation, flow duration curve, dam, & run off river
- Powerhouse – penstock, water hammer, cavitation, tailrace
- Turbines – main types of turbines, their characteristics & their components
- Ocean Power Overview

Suggested reading:

Solar Energy PV

- Green, Martin A., 1981: Solar cells : operating principles, technology and system applications, Prentice Hall.
- Green, M.A., 2007: Third Generation Photovoltaics, Advanced Solar Energy Conversion, Springer Series in Photonics
- Markvart, Tom and Castaner, Luis, 2003: Practical Handbook of Photovoltaics, Fundamentals and Applications, Elsevier Science
- Nelson, Jenny, 2003: The Physics of Solar Cells (Properties of Semiconductor Materials), Imperial College Press.
- Stuart R. Wenham, Martin A. Green, Muriel E. Watt& Richard Corkish (Edit.), 2007: Applied Photovoltaics, Earthscan Publications Ltd.;
- Twidell, John & Weir, Toni, 2005: Renewable Energy Resources Taylor & Francis.

Basics of Wind Energy

- T. Burton et. al.: Wind Energy Handbook. John Wiley, New York, 2nd ed., 2011
- R. Gasch, J. Twele: Wind Power Plants. Springer, 2nd ed., 2011

Fuel Cells & Energy Storage

- Larminie/Dicks: Fuel Cells Systems Explained, 2000, (Wiley, 2000, ISBN 0-471-49026-1)
- EG&G Services, Parsons Inc.: Fuel Cell Handbook, (DE-AM26-99FT40575, 7th Edition, 2005; www.fuelcells.org/fchandbook.pdf)
- G. Hoogers (Ed.): Fuel Cell Technology Handbook, (CRC Press, Boca Raton/London, 2003, ISBN 0-8493-0877-1)
- C.-J. Winter/J. Nitsch: Hydrogen as an Energy Carrier (Springer-Verlag, Heidelberg/N.Y., 1985, ISBN 0-387-18896-7/3-540-18896-7)
- O'Hayre/Cha/Colella/Prinz: Fuel Cell Fundamentals, (Wiley, 2009, 2nd ed., IBSN 978-0-470-25843-9)
- C.H. Hamann, A. Hammett, W. Vielstich, Electrochemistry, 2nd Ed. Wiley, Weinheim 2007
- D. Pletcher, A First Course in Electrode Processes. The Electrochemical Consultancy, 1991.
- A.J. Bard, L.R. Faulkner, Electrochemical Methods, Fundamentals and Applications. 2. Ed., Wiley, 2001.
- M. Winter, R.J. Brodd; What are Batteries, Fuel Cells and Supercapacitors? in Chem. Rev. 2004, Vol. 104, pp. 4245-4269
- A.J. Bard, G. Inzelt, F. Scholz (Eds.) Electrochemical Dictionary. 2. Aufl. Springer, Berlin 2012 (Available as an eBook, very good explanation in English)
- Fischer, W. (1996). Stationary lead-acid batteries - an introductory handbook. Brilon, Germany: Hoppecke.

Biomass Energy

- R. Schlögl (Ed.), Chemical Energy Storage, De Gruyter, 2013, ISBN: 978-3-11-026407-4, Chapter 2, Pages 59-133.
- D.L. Klass. Biomass for renewable energy, fuels, and chemicals, Chapter 4 Virgin Biomass Production, p. 91ff
- Food and Agriculture Organization of the UN (FAO) http://www.fao.org
- IEA Energy Technology Essentials - Biomass for Power Generation and CHP. http://www.iea.org/techno/essentials3.pdf
- R.A. Houghton, Forest Hall, and Scott J. Goetz. Importance of biomass in the global carbon cycle J. Geophys. Res., 114, 2009
- Schlögl, Robert (2013). Chemical energy storage (Elektronische Ressource] ed.). Berlin [u.a.]: De Gruyter.
- Twidell & Weir. Renewable Energy Resources, Chapter 10, http://www.4shared.com/document/HpYwRDPy/Renewable_Energy_Resources_2nd.html
- Wheildon's 2013, http://www.wheildons.co.uk/wp-content/uploads/2013/07/carbon-neutral.jpg
- Waste-to-Energy Research and Technology Council (WtERT), 2009, http://www.wtert.eu/default.asp?Menue=13&ShowDok=12#Hydrolysis

Solar Thermal

- DGS, (2010) Planning and installing solar thermal systems, a guide for installers, architects and engineers, 2nd ed.
- Duffie JA, Beckman WA (2013) Solar engineering of thermal processes: Wiley.
- Kasper, B., & Antony, F. (2004). Solarthermische Anlagen.

Hydro Power

- Charlier R.H., (2009) Ocean Energy: Tide and Tidal Power.

Comments: For EUREC Students is highly recommended to choose the Biomass Energy Lecture in order to achieve a broader overview on different renewable energy technologies.	Helpful previous knowledge: Chemistry, Black Body Radiation, Semiconductor Physics, Fluid Dynamics
Weblink: n/a	Associated with the module(s): Renewable Energy Technologies II
Prerequisites for admission: Enrolment in PPRE, EUREC, EP, Physics, SEM or WCM master programmes	
Maximum number of students / selection criteria 50 (PPRE & EUREC students have priority)	
Requirements for awarding the credit points Written Exam 180min (75% weight, Solar PV+Wind Energy+Energy Storage) Presentation / 15min of a Paper / 15 pages (25% weight, Solar Thermal or Biomass or Hydro Power, PPRE internal conference – refer to module Renewable Energy Technology II)	
Examination periods: Before the end of the lecture period	
Additional Recommendations: Compulsory attendance during the sessions of group work and tutorials	
Registration procedure: Stud.IP	
Last update: 20.07.2017	
Abbreviations: V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical–practical seminar	

School of Mathematics and Science, Institute of Physics,

Module: Fundamentals for Renewable Energy [PRE400]

Duration:	1 semester	Teaching form:	Lectures, Practical training
Cycle:	once a year	Language:	English
Type of module:	mandatory	Attainable credit points:	12 ECTS
Level:	MM (master module)	Workload:	360 hours
This module should be taken in:	1st semester	Required attendance:	80 hours

Person responsible for the study programme: Prof. Dr. Carsten Agert	Persons responsible for this module: Prof. Dr. Carsten Agert, Dr. Robin Knecht
Alternative person(s) responsible for this module: Dr. Herena Torio, Hans Holtorf PhD, Michael Golba, Simone Malz	Examiner(s): the previously named persons

Objective of the module / learning outcomes:

After successful completion of the module students should be able to:

- identify their competence and incompetence with respect to the study of renewable energies
- describe basic knowledge from a wide field of disciplines as required for renewable energies
- perform laboratory measurements in a university environment according to scientific standards
- analyse and interpret measurement results using relevant and widely used software tools
- work and communicate their results with international and interdisciplinary partners
- critically discuss basic principles of current mainstream economics
- distinguish between the classical, neo-classical and selected heterodox economics and relate those approaches to the historic economic development
- distinguish and evaluate the peculiarities of selected energy markets and its regulatory frameworks

Content of the module:

The module is designed to give students a solid foundation to successfully start the MSc programme. The content from the field of Physics, Mathematics as well as Electrical and Mechanical Engineering aims to provide a homogenous foundation for the study of renewable energies via lectures and laboratory experiments. With an introduction into Socio-economics students will learn about the principles of mainstream economics, the peculiarities of energy markets and will get insight into some selected heterodox economic perspectives.

Primers (Lecture & Exercises – 60 h workload)

- Mathematics
- Programming
- Modelling
- Electronic Power Systems
- Semiconductor Physics
- Material Characterization
- Thermodynamics
- Fluid Dynamics

Laboratories (Theoretical–practical Seminar – 120 h workload)

- Introductory Laboratory
- Interaction Light and Matter
- Heat Transfer
- Fluid Dynamics
- Storage Technologies

Introduction to Socio-economics (Lecture & Seminar – 90 h workload)

- Scarcity, market
- Supply and demand
- Equilibrium
- Elasticity
- Incentives, free market, role of the state
- Peculiarities of energy markets and corresponding regulatory frameworks
- Limitations of mainstream economics
- Selected heterodox economics

Suggested reading:
lecture notes for the respective courses

Comments:	Helpful previous knowledge:
Forms of learning: Lectures. The primers are predominantly communicated via reading material and an online forum. On-campus meetings for discussion of difficult issues are provided. (Flipped Classroom). Exercises are provided to each lecture session. The laboratory experiments are performed on campus on dedicated experimental setups. Reading material on the laboratory setups and tasks is given.	n/a
Weblink: n/a	Associated with the module(s) n/a
Prerequisites for admission: none	

Maximum number of students / selection criteria
25 (only registered PPRE students)

Requirements for awarding the credit points
Completing all experiments of the introductory lab during the campus phase. Submission of four lab reports from different categories (50%). Submission of exercises from primers (25%). Country report either in the presentation or written report format (25%).

Examination periods:
At the end of the lecture period.

Additional Recommendations:
n/a

Registration procedure:
Stud.IP

Last update:
20.07.2017

Abbreviations:
V: lecture , Ü: exercise , T: tutorial , S: seminar , PR: internship , Ex: excursion , PG: project team , POM: project oriented module , K: colloquium , W: workshop , EL: e-learning , TPS: theoretical–practical seminar